



1000BASE-T Low-Power Idle Update

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Change summary relative to healey_01_0108

- Update nomenclature to be more in-line with companion low-power idle proposals
- Update protocol to support asymmetric operation of the system without asymmetric PHY operation
- Update protocol to provide advance warning that the Master will enter a quiescent state
- Add explanatory timing diagrams to illustrate these changes

Definition of terminology

- Leveraging hays_01_0308...

Operating / line state	Description
Active	Legacy operating state where data or idle are transmitted.
Low-power	New operating state used during periods of no data transmission, enabling system power reduction between data bursts.
Sleep	New symbols transmitted to inform the link partner that the local transmitter is entering the low-power state.
Quiet	Transmitter(s) are off.
Refresh	New symbols that are periodically transmitted during the low-power state to allows the link partner to refresh timing and equalization.
Wake	New symbols transmitted to inform the link partner that the local transmitter is returning to the active state. These symbols are transmitted for a sufficient time to allow the link partner to prepare to receive data.

More terminology...

- Leveraging hays_01_0308...

Time	Description
T_p	Propagation delay: Media delay.
T_s	Sleep time: Duration PHY transmits sleep symbols before going quiet.
T_q	Quiet duration: Duration PHY remains quiet before sending refresh.
T_r	Refresh duration: Duration PHYs send refresh to enable timing and coefficient update.
T_w	Wake time: Negotiated wait period where no data will be transmitted to allow the receiver to resume normal operation. PHY must be ready to receive data within 10 microseconds but this value may be larger so that the system may emerge from deeper sleep modes.

Low-power idle profile for 1000BASE-T

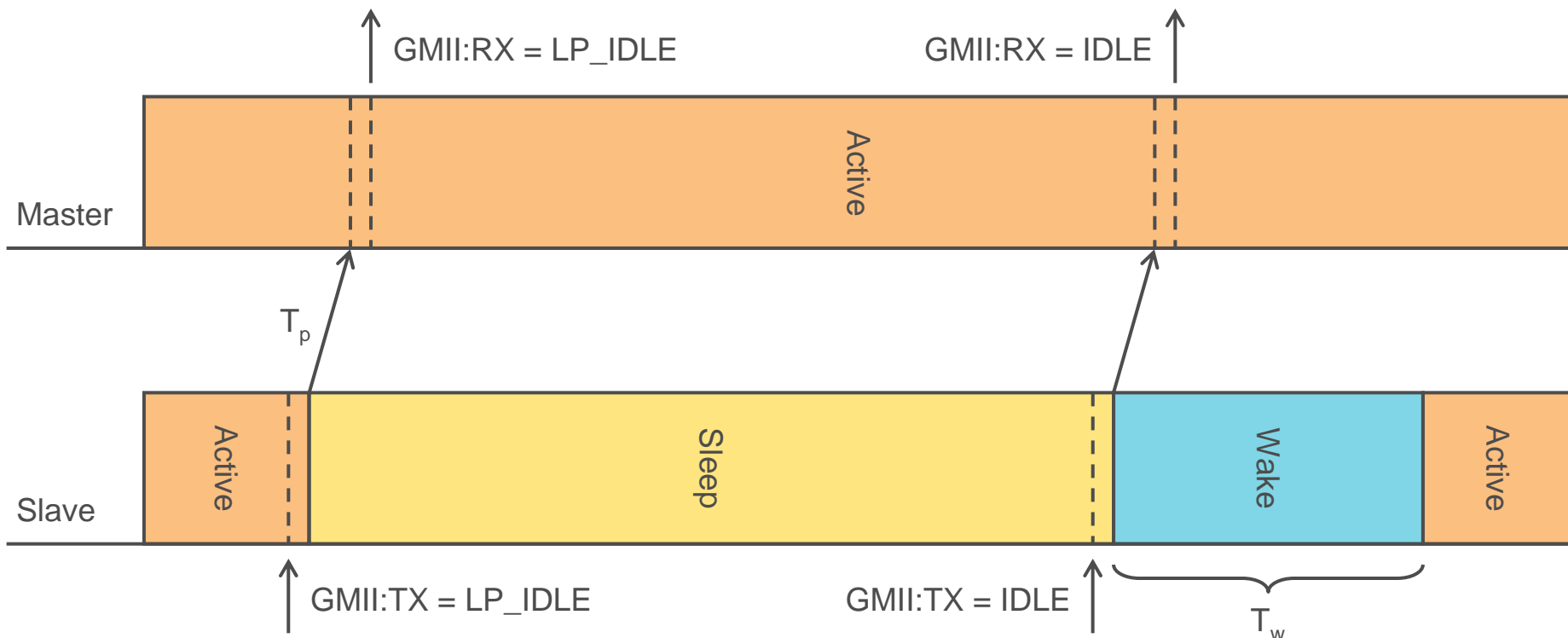
Line state	Description
Sleep	TBD
Refresh	TBD
Wake	TBD

Time	Value
T_p	Approximately 0.5 microseconds
T_s	TBD
T_q	TBD
T_r	TBD
T_w	Negotiated parameter ≥ 10 microseconds

- Line state candidates and PHY specific timing parameters are subjects for further study

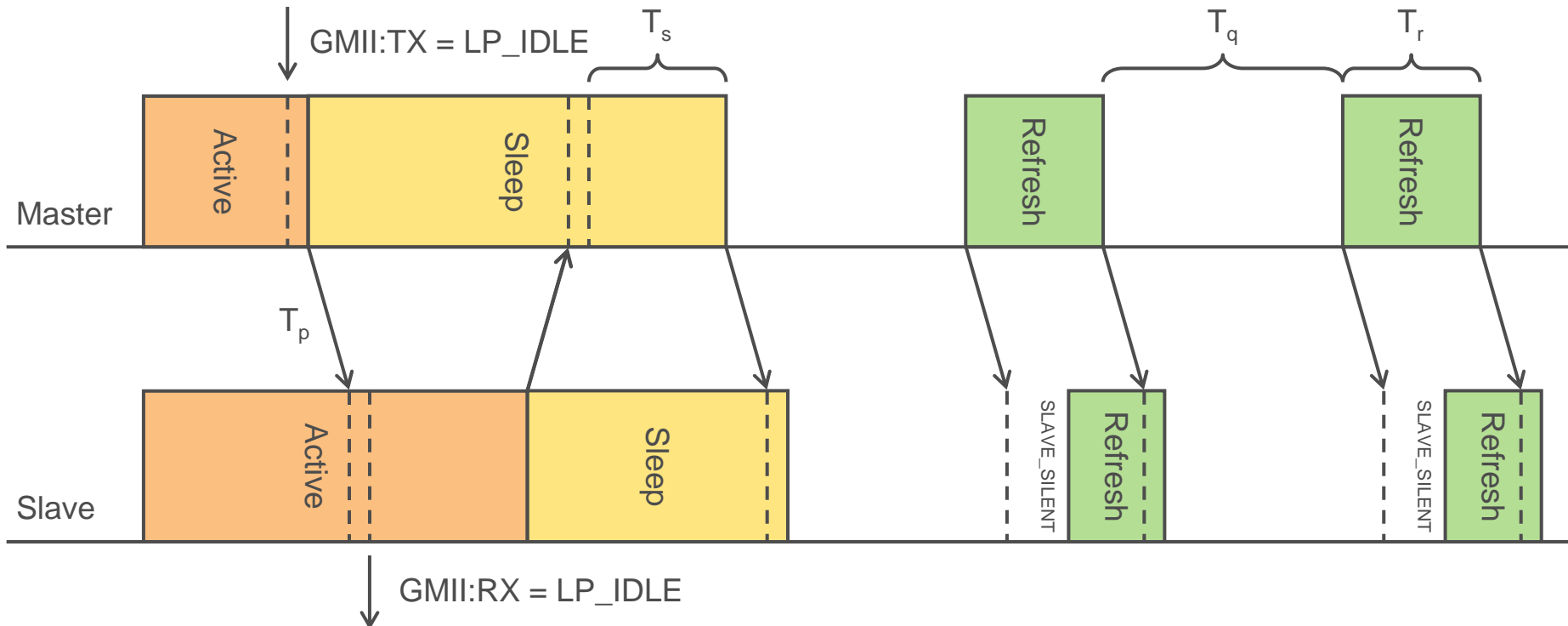
Only slave sleeps

- Support asymmetric low-power system operation with a symmetric PHY
- LP_IDLE signaling on the GMII encoded as the sleep line state
- Sleep line state decoded to LP_IDLE on the GMII
- Similar behavior for “only master sleeps”



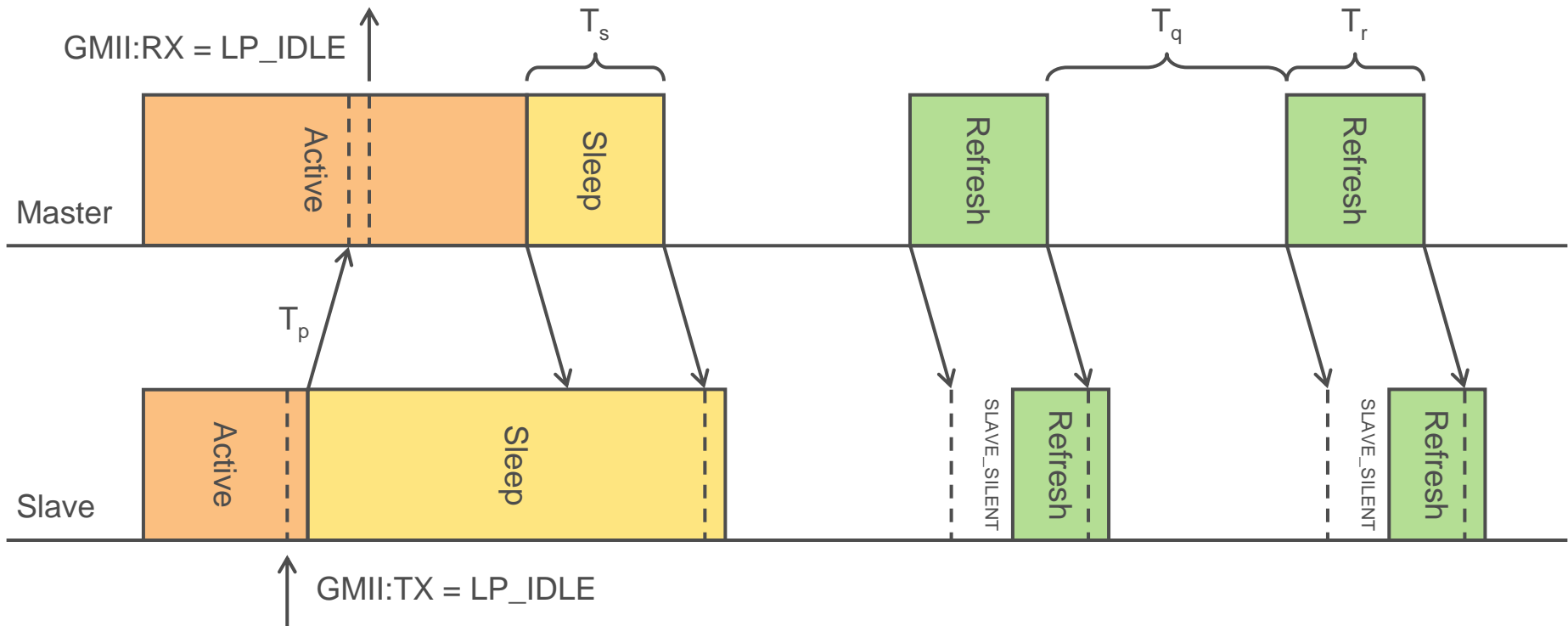
Master first to sleep

- If the Master receives sleep while transmitting sleep, it initiates quiet-refresh cycling (QRC)
- Transmission of T_s sleep symbols provides Master and Slave adequate time to prepare for QRC
- Master dictates QRC timing



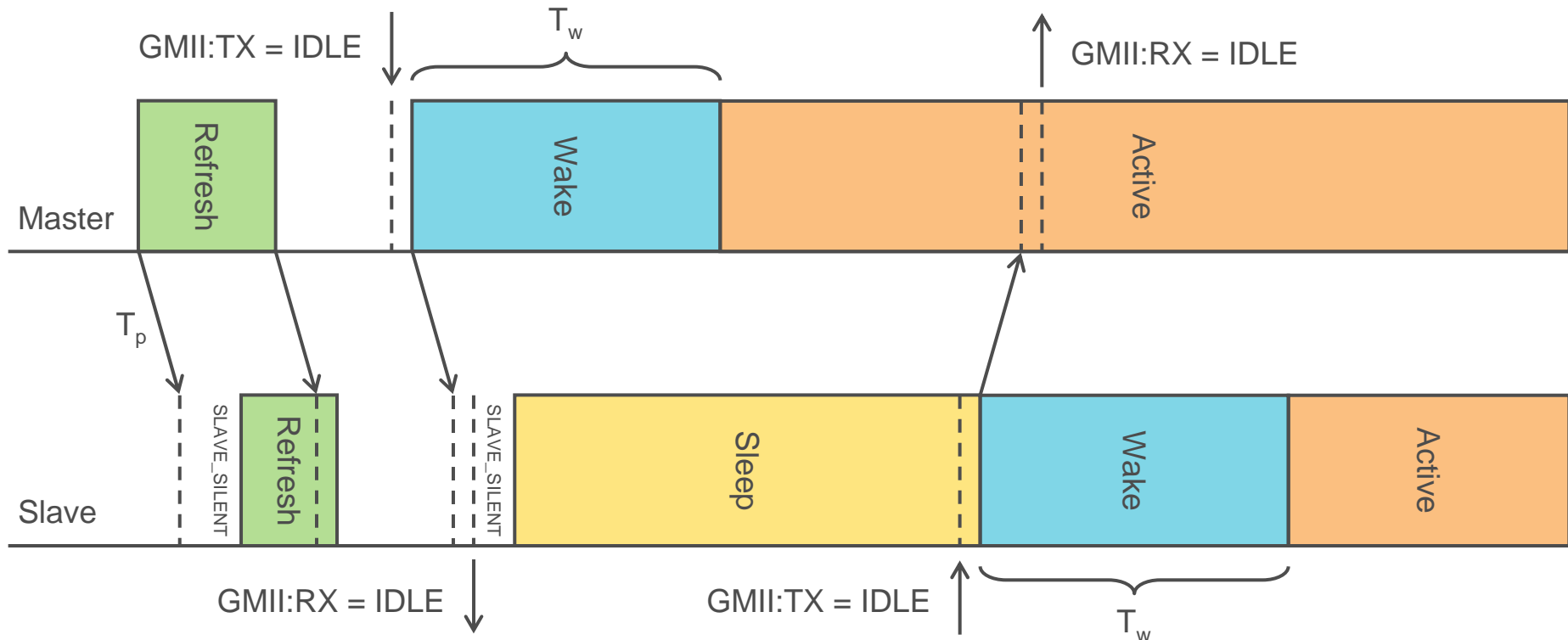
Slave first to sleep

- Refresh cycle modeled after existing 1000BASE-T PHY Control state diagram



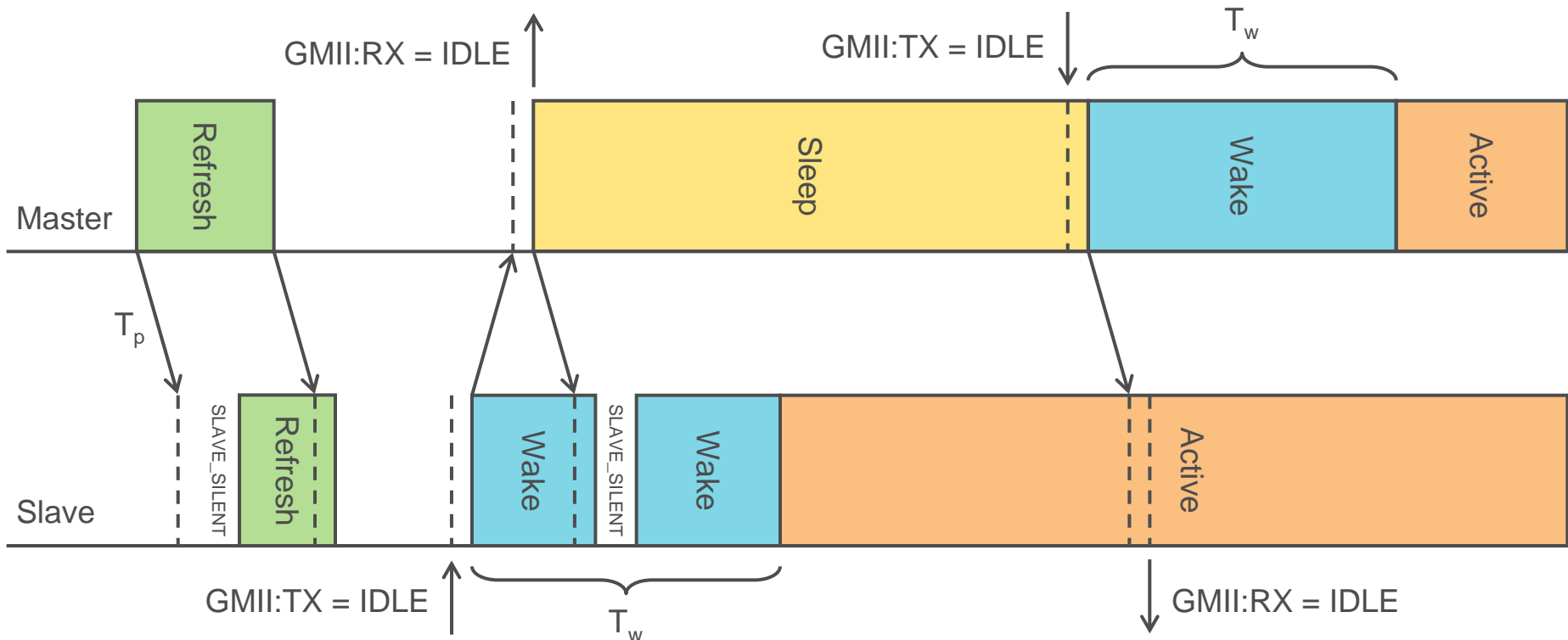
Master first to wake

- System will assume the media is available after T_w hence `rem_rcvr_status` indication is may be used for informative purposes but not a gating condition
- It is imperative that the PHY is ready to receive after T_w (min)

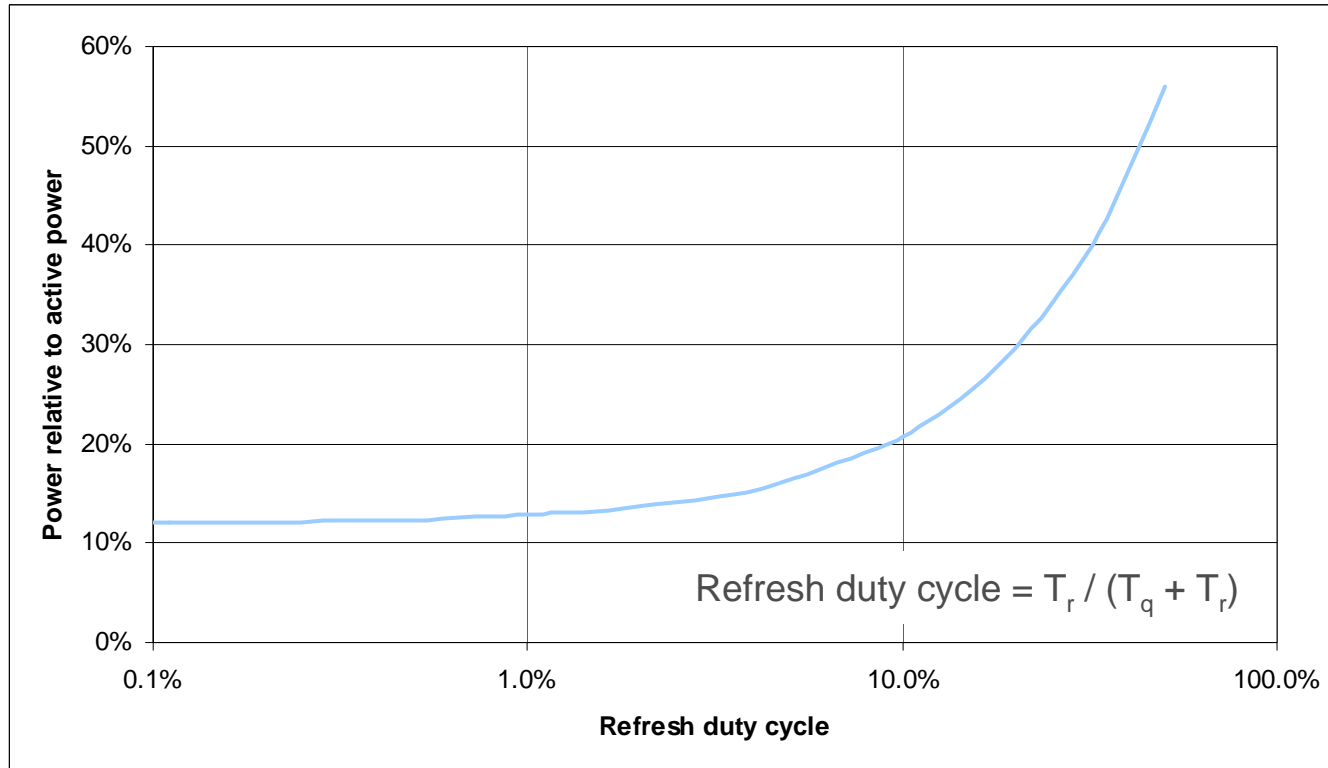


Slave first to wake

- Slave triggers Master to exit QRC, after which the process proceeds as if the Master was the first to wake
- To wake in the midst of the refresh period, the initiator transmits wake symbols (1000BASE-T idle) and the process proceeds as shown



Power reduction during QRC



- Average power during QRC asymptotically approaches quiescent power with decreasing refresh duty cycle
- Less than 1% difference between 1 part in 50 and 1 part in 100



Questions?

